THE GEOMORPHOLOGY OF THE LUNAR SURFACE AS SEEN BY THE MINI-RF INSTRUMENT ON LRO. G. W. Patterson[1], D. B. J. Bussey[1], P. D. Spudis[2], C. D. Neish[1], B. J. Thomson[1], L. M. Carter[3], K. Raney[1], K. Williams[4] and the Mini-RF Science Team, [1]Planetary Exploration Group, Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723, Wes.Patterson@jhuapl.edu, [2]Lunar and Planetary Institute, Houston, TX, 77058, [3]Smithsonian Institutio, Washington, DC 20013, [4]University of Hawai'i, Honolulu HI 96822.

Introduction: Mini-RF is a radar technology demonstration launched on the Lunar Reconnaissance Orbiter (LRO). It is a side-looking, synthetic aperture radar (SAR) that transmits at both S-band (12 cm) and X-band (4 cm) wavelengths [1]. For both the S- and X-band, the instrument can operate in two modes: a baseline mode with a resolution of 150 m and a zoom mode with a resolution of 30 m. Mini-RF measures returned signals in two orthogonal polarizations. This data allows for the calculation of Stokes parameters that are used to produce products such as the circular polarization ratio and the degree of linear polarization [1, 2]. These products provide information necessary to satisfy the primary objective of the instrument: to investigate the possible presence of water ice in permanently shadowed areas near the lunar poles [3]. However, the radar data collected can provide a wealth of additional information about the lunar surface, such as surface roughness, dielectric properties, and topography. Properties such as roughness may not be as obvious in the visible or infrared image data, so these data are complementary to the data acquired by other instruments on LRO, such as LROC [4]. Further, the relatively large penetration depth of the radar (several meters) allows for sampling of the near subsurface. Here we describe some of the unique capabilities of this radar instrument with regard to analyzing the geomorphology of the lunar surface.

Lunar Geomorphology: In examining the geomorphology of the lunar surface, we utilize S-band zoom data covering non-polar targets across the Moon. Specifically, the radar images we use to interpret surface morphology represent the S_1 component of the Stokes vector. This component corresponds to the total average power in the signal. With this data we examine ejecta deposits associated with fresh craters and interior deposits associated with complex craters.

Ejecta deposits. Variations in radar backscatter can serve as a measure of surface roughness [2]. Since the radar receiver is co-located with the radar transmitter, smooth surfaces tend to specularly reflect the radar beam away from the receiver, resulting in a low return, whereas rough surfaces cause the beam to be scattered in many directions, resulting in a higher return. Young, fresh craters are distinctive in radar images obtained with the Mini-RF instrument because of the surface roughness associated with their ejecta deposits.

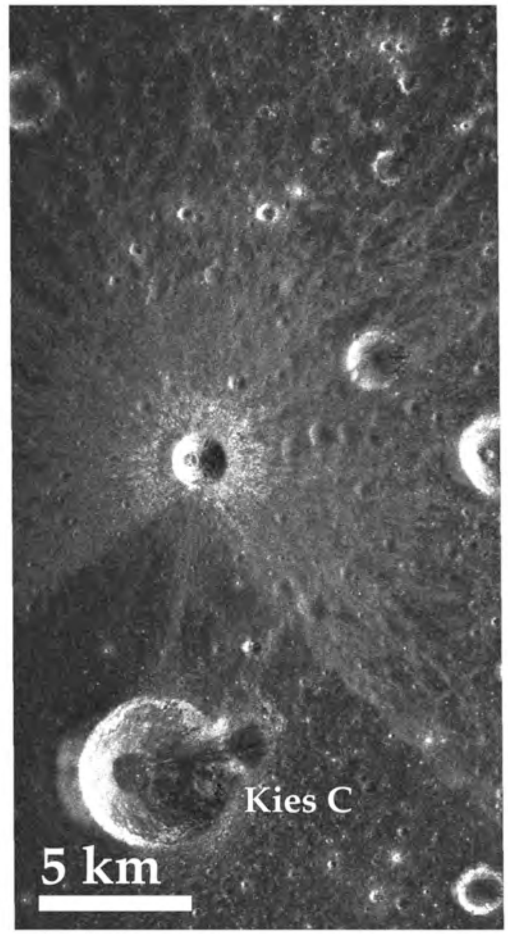

Fig. 1. S-band zoom image of a fresh crater found in south-western Mare Nubium. The doublet crater Kies C is located at 26°S, 334°E.

To illustrate, we show two examples of young, fresh craters with unique characteristics associated with their ejecta. The first is an example of an oblique impact, as evidenced by the uprange zone of avoidance (i.e., absence of ejecta deposits) that is observed (Fig. 1) [5]. With this crater, we see radar bright deposits immediately exterior to its rim that are superposed on darker and more extensive deposits. These deposits represent the continuous and discontinuous ejecta of the crater, respectively. The second example is a young fresh crater formed on the floor of the larger crater, Kopff (Fig. 2). Here we observe ejecta from the fresh crater that have been deposited beyond Kopff's rim.

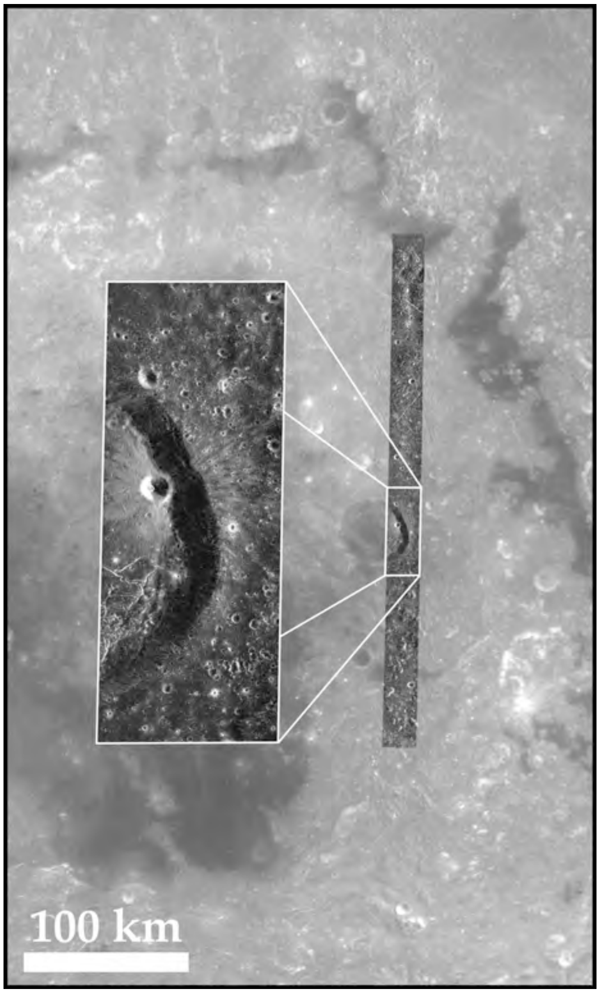

Fig. 2. Image of Kopff crater within the Orientale basin. The S-band zoom strip covers the eastern third of Kopff. It stretches from 21ºS to 11ºS latitude and is centered at ~270.5ºE longitude. The radar data has been overlain on Clementine UVVIS data at a resolution of 128 ppd. The inset (~30 m resolution) shows an unnamed crater within Kopff with ejecta deposits that extend beyond its rim.

Interior deposits. Variations in radar backscatter can also serve as an indication of topographic variability [6]. This is related to the orientation of slopes with respect to the look direction of the radar instrument. This aspect of radar data is particularly advantageous for examining the morphology of interior and exterior deposits associated with complex craters. One such example is King crater (Fig. 3). Complex topography associated with the walls and floor of the crater lead to a strong radar return and stand in stark contrast to the lower return from a presumably associated impact melt deposit north of and immediately exterior to the rim of the crater. The return suggests the melt deposit is flat with a low roughness, the latter of which was unexpected and is currently being studied.

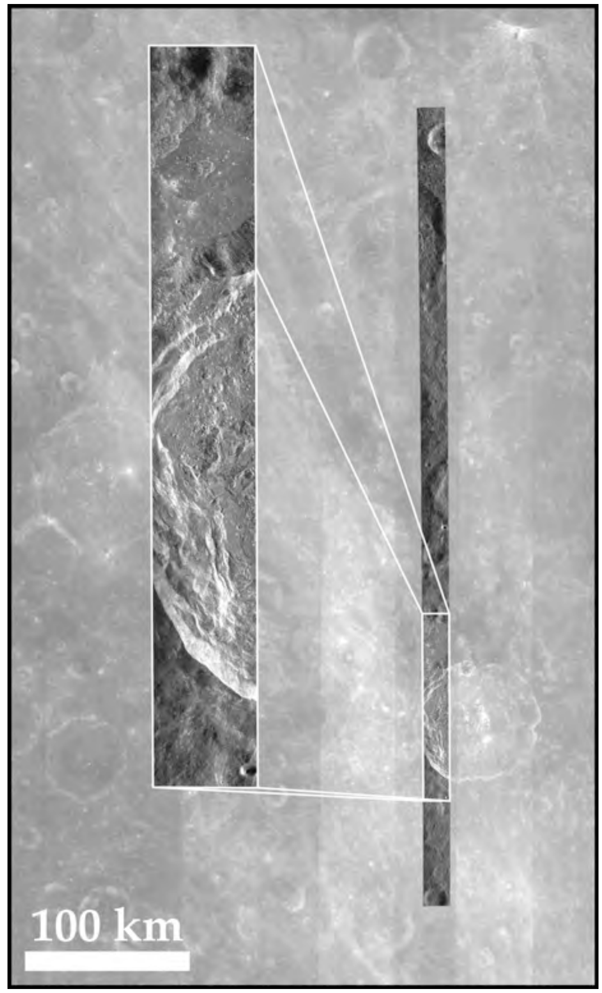

Fig. 3. Image of the lunar farside crater, King. The S-band zoom strip stretches from 1ºN to 17ºN latitude and is centered at ~119.5ºE longitude. The radar data has been overlain on Clementine UVVIS data at a resolution of 128 ppd. The inset (~30 m resolution) shows the complex interior morphology of the crater along with a presumably associated impact melt deposit exterior to the rim of the crater.

Summary: The Mini-RF instrument on LRO provides important data regarding the surface roughness, topography, and dielectric properties of the lunar surface. The information gained from this data provide a unique perspective in understanding the evolution of the lunar surface.

References: [1] Chin et al. (2007), *Space Sci. Rev.,* doi:10.1007/s11214-007-9153-y; [2] Raney (2006), *IEEE Geosci. Rem. Sens. Lett., 3*, 317; [3] Bussey et al. (2003) *GRL, 30*, 7158; [4] Mechtley et al. (2010), *LPSC XLI*, this conference; [5] Melosh (1989), *Impact Cratering*, Oxford University Press; [6] Wildey (1986), *Photo. Eng. Rem. Sens.*, 52, 41-50.